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ON THE

TELESCOPIC APPEARANCES OF SATURN

WITH A $7\frac{1}{2}$ INCH TELESCOPE.

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WITH A $7\frac{1}{2}$ INCH TELESCOPE.*

IN the spring of last year (1854) I availed myself of an opportunity of increasing the optical means in my possession, by the purchase of a $7\frac{1}{2}$ -inch object-glass, having a focal length of nearly $9\frac{1}{2}$ feet. It is the work of Mr. Alvan Clark, of Boston, U. S., who has long been known in that city as a most successful painter of portraits, but took to the manufacture of telescopes as an amateur. Being dissatisfied with reflectors, on which he commenced his operations, he attempted the manufacture of object-glasses; and succeeded so well, that in the autumn of 1851 he communicated to me the places of some new and very close double stars, which he had discovered with glasses whose apertures were $4\frac{3}{4}$ and $5\frac{1}{4}$ inches. In the following year he completed an object-glass of $7\frac{1}{8}$ inches aperture for the observatory at Williams College, which was tried at the Harvard Observatory by the Messrs. Bond, and highly approved; immediately after which he commenced one of $7\frac{1}{2}$ inches aperture, intended to be retained and mounted equatorially for his own use. At his request I sent him some extremely difficult tests, selected from Mr. Otto Struve's *Pulkova Catalogue*; several of which have a central distance of little more than half a second, and some even less. Yet of all these I soon received from the ingenious maker (who has also proved himself an acute observer) perfectly correct diagrams; together with the places of one or two extremely difficult new double stars which he had discovered with this glass. As a specimen of these, I may mention 95 *Ceti*, which is at present favorably situated for observation. Though unwilling to part with this glass, Mr. Clark consented to let me have it to try against my Munich telescope; and in March, 1854, it arrived, with its tube, finder, and eye-pieces.

Though the crown-glass has a considerable number of small bubbles, the performance of the telescope is not sensibly affected by that circumstance. In other respects the materials are good; and the figure is so excellent, and so uniform throughout the whole of the area, that its power is quite equal to anything which can be expected of the aperture; and consequently, both in its illuminating and separating power, it is decidedly superior to my old favorite of $6\frac{1}{8}$ inches aperture. As a specimen of its light, I may mention the companion of ν *Ursæ Majoris* as having been pretty steadily seen with it; and also that I have never seen *Saturn* under tolerable circumstances during the present apparition without detecting *Enceladus*, even when at or very near his con-

* Extracted from the Monthly Notices of the Royal Astronomical Society for Jan. 7, 1855.

junctions with the planet. When exterior to a tangent to the extremity of the ring, this satellite has frequently been perceived as soon as my eye was applied to the telescope. Last spring it was seen several times in strong twilight; for instance, on March 16th, 17th, and 20th, at about 7^h G. M. T. In separating power, the glass is competent to divide a sixth-magnitude star composed of two equal stars, whose central distance is $0''\cdot6$.

I have thought it proper to premise thus much respecting the performance of the telescope, that a correct idea may be formed as to the degree of dependence to be placed upon the views it has afforded me of *Saturn*; the special subject of my present communication, to which I will now proceed.

1. *The outer Ring A.*—The interior edge of this ring is decidedly its brightest part: its light rapidly fades away towards the middle, where there is a very dark, narrow, well-defined line concentric with the ring, and about one-fifth of its breadth by careful estimation. This line has been always seen when the air was in a tolerably good state, and much more readily than last year. On the 26th of November, 1854, it was traced more than half way round towards the ball, and was equally well seen at both ansæ. I have recorded on 10th January, 1855, "I am surprised at the positiveness of the dark line near the middle of this ring. It was well seen with every power from 355 to 1000." This is now the fourth apparition of *Saturn* in which I have noticed this dark line, and it does not appear to me to have varied in its position on the ring, or in its breadth and depth of shade.

2. *The interior bright Ring, B.*—The concentric shaded bands on this ring have been on two or three of the most favorable occasions very well brought out. On this appearance I find the following notes in my journal:—

"1854, Nov. 26. The ring B is decidedly in *stripes*, and they are not *regularly* darker from the exterior one inwards. About one-fifth of the breadth of the ring, from its exterior edge, is very bright; then a narrow stripe is lightly shaded; immediately within that is a stripe decidedly lighter, though not so bright as the exterior fifth; next to that is a considerably darker stripe, and then a *much* darker one extending nearly to the interior edge, where there is a *very* narrow *bright* line, far less decided than it was in 1851 and 1852."

"Dec. 7. By brief views the step-like character of the shading on ring B is visible; and I think the *outer* shaded band is *darker than the next interior one*, as I noticed one night before."

"1855, Jan. 10. The bands of shading towards the interior edge of this ring are occasionally well brought out; and I think the *second* from the outside is not quite so dark as the first,—at least in some parts of it, for I doubt if it be quite uniform. The narrow bright line at the interior edge is visible, but is not, I think, so bright as it was in the two previous apparitions."

3. *The obscure semi-transparent Ring C*, has been very well seen on several occasions ; and I have noticed nothing remarkable about it except the occasional variations of its tint in different parts. Respecting this I have recorded as follows :—

“1854, Sept. 26. The dark ring is plainly seen, and appears to-night of the same tint at both ansæ. Its semi-transparency is very obvious across the ball, the edges of which can at times be distinctly traced down to the inner edge of ring B.”

“Dec. 26. The dark ring is remarkably clear : the following end is *ruddier* than the preceding.”

“1855, Jan. 10. The ring C is wonderfully well seen in general : rather ruddy on the preceding side, slate-colored on the following side. The ball is seen plainly, though faintly, through it.”

4. *The Ball*.—Of its appearances I have the following notes :

“1854, Sept. 26. The belts on the ball are not very distinct. The southern boundary of the broad dark belt, which is immediately south of the equator, is *not uniform*, or parallel to its northern edge. Tho belt therefore, varies in breadth in different parts, and is at present (13^h 45^m G. M. T.) broadest near the eastern edge of the ball. There is a very narrow light line seen interruptedly crossing the belt from east to west, a little south of its middle. The rest of the southern hemisphere is nearly uniform in color, except that round the south pole is a belt of rather darker tint, and at about 40° of south latitude there is a very narrow belt less dark than the polar one.”

“Dec. 7. The annexed sketch” (in the journal) “shows the form of the shadow of the ball on the ring B. It does not extend to the ring A at all ; but I think a very small portion ($0^{\circ}2\pm$) of the southern edge of the ball is projected upon A.”

“Dec. 16, 12^h 30^m \pm G. M. T. The south pole, or rather the most southerly part of the ball, is very dark,—much darker than the ring A, and I think rather darker than the broad belt near the equator. This renders the contrast with the small visible portions of its shadow less evident. I feel pretty sure that the southern edge of the ball encroaches a trifle on the ring A. There are no distinct and well defined belts on the ball now.”

“1855, Jan. 10, 9^h \pm G. M. T. The whole of the southern hemisphere of the ball is ruddy, and the parts near the equator and at the southern edge are the darkest. Examined very carefully, and with all the various powers” (extending from 355 to 1000), “the position of the southern edge with respect to the edges of the rings at that part. The edge of the planet is so dark that it gives the impression sometimes of having a dark line there marking its contour. This darkness of the shading, at the very edge of the ball, renders it difficult to distinguish it from the division between the rings. But after long and careful examination, I am satisfied that *the ball extends over the division, and en-*

croaches $0''.2$ or $0''.3$ on the ring A. By carrying my eye across from the black division on one side to the other, I can see that, if continued in an uninterrupted line, it would cut off a thin slice from the edge of the ball. With very high powers (705 to 1000) the difference of color of the southern edge of the ball, and the ring A at that point is more marked than with the lower powers; and long scrutiny with them confirms my impression that the ball encroaches slightly on A."

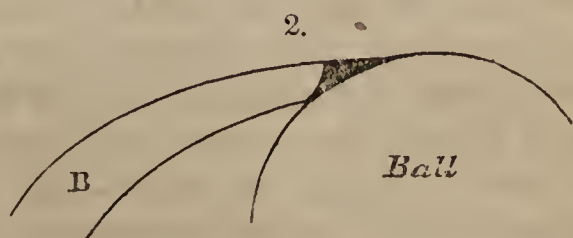
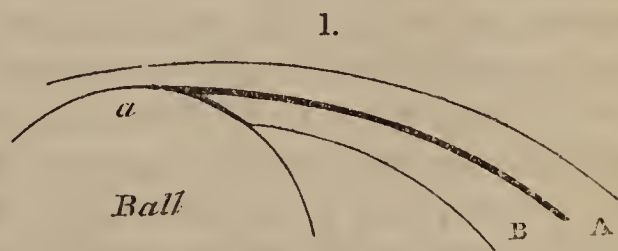
"10^h 36^m ± G. M. T. Applied an excellent Huygenian eye-piece, giving power 860. It is admirable. The difference of color of the southern edge of the ball and ring A is obvious; and there is no doubt at all of the slight encroachment of the ball on its interior edge. Finding the light of the planet produce a very unfavorable effect upon my eye while endeavoring to estimate the degree of encroachment of the ball on A, it occurred to me to apply my solar eye-piece for the purpose of excluding the rest of the ball and rings, and leaving visible only the southern portion of the ball and the adjacent portion of the rings A and B. Power 506 (the highest, a double-convex lens). The effect is admirable. My eye having rested upon it for some time, the outline of the southern edge of the ball was far more distinctly seen than before, and leaves no doubt of its encroaching on the interior edge of A, to about $0''.3$ by careful estimation. At times a little mottling can be discerned very near the southern limb of the ball. Its color is very different from that of ring A; and it completely interrupts the black division which comes sharply up to the ball on both sides of it."

5. *The Shadow of the Ball on Ring B.* On this appearance I have noted as follows:—

"1854, Sept. 26. The shadow of the ball on ring B is nearly a straight line."

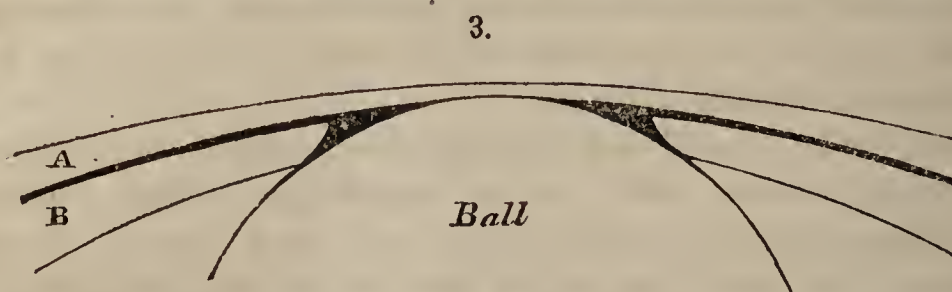
On Sept. 29 the projecting portion of the shadow, which has been noticed the last two or three years, was seen for the first time this season on the eastern side of the ball; cutting off the acute point of the ring B intercepted between the edge of the ball and the black division, as at *a* in the sketch, in which the appearance is much exaggerated.

At the same date I have remarked,—“I doubt if the shadow of the ball on ring B is really a straight line, though nearly so. It seems to be a little curved towards the southern end of it, close to the division.” In the place indicated the edge is convex towards the ball.



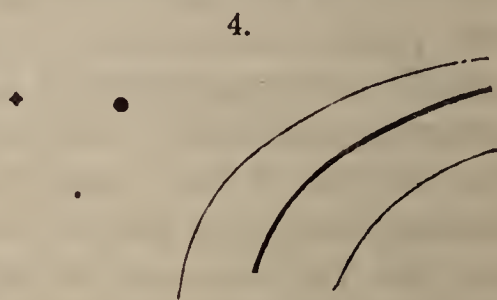
“Nov. 26. Only a *very* narrow line of shadow from the ball falls on the west side, but there is a curious angular projection in the shadow on both the west and east sides of the apex of the ball.”

“Dec. 7. The annexed sketch shows the form of the shadow



of the ball upon ring B.” (Exaggerated in the sketch as respects the *size* of the shadow.)

6. *The Satellites.*—I have usually estimated *Tethys* to be brighter than *Dione*, even when it has been nearer to the planet. This was remarkably the case on the 10th of this month, at $7^{\text{h}} \pm \text{G}$. M. T., when both the satellites were near their greatest western elongation. At $11^{\text{h}} 19^{\text{m}}$ G. M. T., *Dione*, *Tethys*, and *Enceladus*, formed an equilateral triangle south-preceding the western end of the ring, thus,—



In No. 929 of the *Astron. Nachrichten*, is a most interesting account by Professor Secchi of the appearance of *Saturn* in the Munich equatorial refractor, recently erected at the Observatory at Rome. The dimensions of the telescope are the same as those of the Dorpat refractor, the aperture of the object-glass being 9 Paris inches. The Professor characterizes the night of Nov. 19 as one of extraordinary excellence, and doing full justice to the telescope. He describes the dark line on ring A as being just like a *pencil line* drawn upon it, which perfectly agrees with the views I have had of it since 1851; and with my description as “narrow, very dark, but not black.” And when the dusky hue of the ring A is considered, it seems probable that this line would appear almost black if contrasted with a much brighter ground, such, for instance, as the exterior edge of the ring B. It deserves to be remarked that a dark line, precisely similar to this in appearance and situation, was seen on the *northern* surface of this ring, in the year 1838, by Professor Encke; and by Mr. Lassell and myself in 1842 (when we were not aware of Encke’s observation). It may not be a *division* in the ring, as it was then supposed to be; but, if it is not, it is certainly extraordinary that precisely the same appearance should exist *on both surfaces of the ring*, and should be, as it would seem, a permanent phenomenon in respect of its situation on the ring, and the darkness of its shade.

Professor Secchi has also described the step-like concentric bands of shading on ring B, exactly as they were described by myself on October 26, 1851: and as I have occasionally seen them almost precisely in the same way to the present time, it may fairly be concluded that they form a permanent feature of this ring. The Professor does not notice the *comparatively bright line* at the interior edge of B, which seems to me to render that edge pretty definite, though it is certainly less bright now than it was two or three years ago.

In one important point the impression received by Professor Secchi differs decidedly from my own, as stated in the present paper: viz., the place to which the southern edge of the ball is seen to extend on the rings. He states that the opening of the ring is such, that *the upper edge of the ball exactly touches the interior edge of the black division between A and B*, which was visible throughout the whole of its elliptic perimeter. It is singular that, on the 26th of September I arrived at precisely the same conclusion; but the state of the air was not such as to permit the advantageous use of high powers; and my subsequent observations, under much better circumstances, and especially on the 10th of this month, convinced me that my first impression was erroneous, or that a change to a considerable, and in fact *unaccountable*, amount had taken place.

The *first* satellite of *Saturn* (now usually called *Mimas*) is stated by Professor Secchi to have been seen on November 19th, near its great western elongation; having been found by putting the planet nearly out of the field, and afterwards seen steadily with the planet in full view. It is surprising that he does not mention *Enceladus*, which must have been close to *Mimas* at that time, if the latter occupied the place indicated. As my telescope has not shown me *Mimas*, I cannot say where that satellite might have been; but my own observations prove that *Enceladus* occupied precisely the situation which the Professor has ascribed to *Mimas*; and I cannot but think it probable that further observations may have convinced him that it was not the *first*, but the *second*, satellite which he saw.

The *bright zone on the ball*, which commences almost precisely at the equator, and extends northwards as far as the ring permits it to be seen, forms one of the most conspicuous features of the planet. It has been repeatedly referred to by Professor Secchi, as *caused by the reflection of the sun's light from the surface of the ring*. Two considerations seem to me to be quite conclusive against its arising at all from that cause. One is, that this bright zone occupied precisely the same situation, and was very conspicuous, *when the plane of the ring passed through the sun*. (See "Remarks on the Planet Saturn," by the Astronomer Royal, in the *Greenwich Observations* for 1844, p. 44.)

The other is, that the reflection of the sun's light from the *southern* surface of the ring, which now receives it, must necessarily fall upon the *southern* hemisphere of the ball, which has been remarkably dark ever since the southern surface of the ring has been illuminated; while the bright zone lies wholly in the *northern* hemisphere. The remarkable obscurity of the southern hemisphere at the present time seems to indicate that the effect of the reflection from the surface of the ring is quite inappreciable as seen from the earth.

Wateringbury, Jan. 11, 1855.

Postscript.—“Jan. 14. The night proving fine, I again carefully examined *Saturn*, and made the following entry in my journal:—

““ 12^h 45^m G. M. T. *Saturn* is very fine at times, though about 3³/₄^h past the meridian. It bears 705 very well; and with this power I have no doubt of the southern edge of the ball extending over the division between A and B, and encroaching a trifle on the interior edge of A. With low powers (355 or less) there is sometimes an appearance of the division extending across; but I am persuaded that this arises from the combined effect of the division coming up on each side so near the apex, and the *very* deep tint of the apex itself, which I think is *darker* than the darkest part of the broad belt close to the equator of the planet. It is certainly much darker than the ring A.’”

